

A Comparison of the Chemical Composition of
Artificially Produced Parthenocarpic Fruits
and Normal Seeded Fruits of Peppers

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A Comparison of the Chemical Composition of Artificially Produced Parthenocarpic Fruits and Normal Seeded Fruits of Peppers¹

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IN a previous report the author (5) showed that there were differences in the carbohydrate and acid contents of parthenocarpic and seeded tomato fruits. The parthenocarpic fruits had a higher percentage of carbohydrate than the seeded fruits. This difference was mainly in the locular region. The titratable acid of the parthenocarpic fruits was only slightly lower than that of the seeded fruits; however, the distribution of acid was different in the two types of fruits. The titratable acid was approximately the same in the different regions of the parthenocarpic fruits, but it was much higher in the locular region and lower in the pericarp of the seeded fruits than the average for the entire seeded fruits. This report deals with similar studies made on parthenocarpic and seeded pepper fruits.

MATERIALS AND METHODS

Fruits of *Capsicum annuum* variety California Wonder, grown in the field at the University of Michigan Botanical Garden, were used in these experiments. Parthenocarpy was induced by the method developed by Gustafson (1), using 1 per cent indole butyric acid in lanolin as the stimulant. Each day that flower buds were treated with indole butyric acid the same number of blossoms which had already opened were pollinated and labeled for controls. Parthenocarpic and seeded fruits to be compared were picked at the same time. They were picked from the same plant or from similar plants growing close together.

Pepper fruits do not all ripen at the same age, so that it is necessary to have some other criterion than age as a measure of their maturity. Color, which was used as a measure of ripeness in the tomato studies, proved very satisfactory in these investigations as well. For the more immature fruits, however, the age served as a good indicator of the physiological state. Samples of the following stages were obtained: 15-, 33-, and 47-day-old fruits harvested according to age; dark green, averaging 58 days old; green with some red, averaging 62 days old; red with some green, averaging 64 days old; and all red, averaging 68 days old; harvested according to color. Two set of samples were obtained for each stage with the exception of the 58-day-old fruits for which there was only one sample. The 15-, 33-, 47-, and 58-day-old

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samples contained 10 to 14 fruits per sample. Because of the poor set of fruit and the injury caused by hot weather, the samples of the 62-, 64-, and 68-day-old fruits contained only four to six fruits each.

The fruits were separated into pericarp, placenta, and seeds, when present. The pericarp was cut up into pieces about $\frac{1}{4}$ inch square and each sample thoroughly mixed. Samples for dry weight determinations and juice analyses were taken from these larger samples. The dry weight was determined by drying 100 grams fresh material to constant weight in a vacuum oven at 60 degrees C. The dried samples were saved for carbohydrate and nitrogen determinations. The samples of placenta were divided into two parts, one for dry weight and the other for juice analyses.

The titratable acid of the juice was determined by using .05N NaOH with phenolphthalein as an indicator. The pH was determined with a Beckman pH meter and the soluble solids with an Abbé refractometer. The reducing and total sugars were determined by extracting the dried samples with 80 per cent ethyl alcohol and determining the reducing power of an aliquot of this extract by the Hagedorn-Jensen method (3, 4). Nitrogen determinations were made on a semi-micro scale using selenium as a catalyst in the digestion.

RESULTS

As was observed by Gustafson (2), the parthenocarpic fruits have a somewhat different shape than the seeded ones. The stylar end in the parthenocarpic fruits was quite sunken. This made them shorter than the seeded fruits which normally are more or less round at the stylar end. The width of the two types of fruits was approximately the same.

By the time the fruits had reached the 15-day-old stage the seeded ones were definitely heavier than the parthenocarpic ones, and from this stage on they both increased in weight at such a rate that the ratio between the two remained more or less constant. The weight of the seeded fruits was one and a half to two times that of the parthenocarpic ones.

Another striking difference in the development of the fruits was in the placenta. Those of the parthenocarpic fruits consisted of three or four ridges which were not joined in the center; in the seeded fruits they consisted of thick ridges connected to a large central axis. In the fully developed fruits the placenta of the parthenocarpic fruits made up about 3 per cent of the whole fruit, while those of the seeded fruits made up about 6 per cent. Approximately 1 per cent of the seeded fruits was seeds.

In contrast to the tomatoes (5), peppers show very little difference between the parthenocarpic and seeded fruits in the acid content or pH. There is normally less acid in pepper fruits than in tomato fruits. The acidity, as measured by the amount of NaOH neutralized, increased in both types of pepper fruits as they ripened. There was slightly more acid in the placenta than in the pericarp of the same fruit, but there was no significant difference in acidity between the parthenocarpic and seeded fruits. The pH decreased somewhat with the increase in acidity.

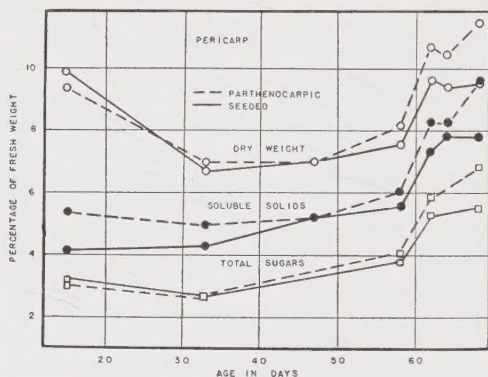


FIG. 1. Changes in dry weight, soluble solids, and total sugars of the pericarp of parthenocarpic and seeded pepper fruits.

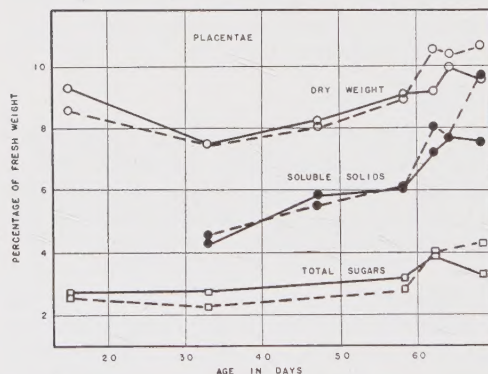


FIG. 2. Changes in the dry weight, soluble solids and total sugars of the placenta of the parthenocarpic and seeded pepper fruits.

placentae of the seeded fruits.

During the spring of 1940 a few peppers were grown in the greenhouse. The dry weight of 17 parthenocarpic and 12 seeded fruits was determined. The fruits varied in color from mostly green to red ripe. The average percentage of dry weight for the parthenocarpic fruits was 9.8 and for the seeded fruits it was 9.1. These data would indicate that the environment did not have much effect on the relation of the percentage of dry weight between the two types of fruits.

The pericarp of the 15- and 30-day-old parthenocarpic fruits had a higher percentage of soluble solids than the seeded ones. From this stage on the curves for soluble solids resembled those for dry weight. The soluble solids in the pericarp of the red ripe parthenocarpic fruits was nearly 2 per cent higher than that of the red ripe seeded fruits. The fruits of the red ripe stage were the only ones in which the placenta of the parthenocarpic fruits had a significantly higher percentage of soluble solids.

but here again there was no difference between the seeded and parthenocarpic fruits.

Figs. 1 and 2 show the changes in percentage of dry weight, soluble solids and total sugars which took place in the pericarp and placenta of the pepper fruits as they developed. The curves show that the dry weight as percentage of the fresh weight was nearly equal in both types of fruits until they began to ripen. During the ripening process the dry weight as percentage of fresh weight increased in both types of fruits but at a more rapid rate in the parthenocarpic ones. The dry weight of the pericarp of the red ripe parthenocarpic fruits was approximately 2 per cent higher than the dry weight of the seeded fruits. The dry weight of the placenta of the red ripe parthenocarpic fruit was approximately 1 per cent higher than the dry weight of the

The changes in sugar expressed as percentage of fresh weight paralleled very closely the changes in percentage dry weight in both the pericarp and placentate. There was from 1 to 1.5 per cent more sugar in the red ripe parthenocarpic fruits than the red ripe seeded fruits.

If the carbohydrates are calculated on a dry weight basis an entirely different picture is obtained. On this basis all of the constituents which were analyzed, with the exception of nitrogen, showed no differences between the two types of fruits, regardless of the stage at which they were studied. This fact would indicate that the main difference between the parthenocarpic and seeded pepper fruits was one of hydration and not an actual change in the relative proportion of the different constituents.

Total nitrogen is the only constituent other than moisture in which a consistent difference between the parthenocarpic and seeded fruits was found. When expressed as percentage of dry weight the total nitrogen was higher in the pericarp of the parthenocarpic fruits than in the seeded ones at all stages except the 15-day-old fruits (Fig. 3). Eight samples varying in age from 30 to 68 days were analyzed. There was an average of 0.25 per cent more total nitrogen in the parthenocarpic fruits. The standard error of this difference was ± 0.034 , indicating a high degree of significance.

The percentage of alcohol soluble nitrogen was slightly different at the 30- and 58-day-old stages but was the same at the other stages studied.

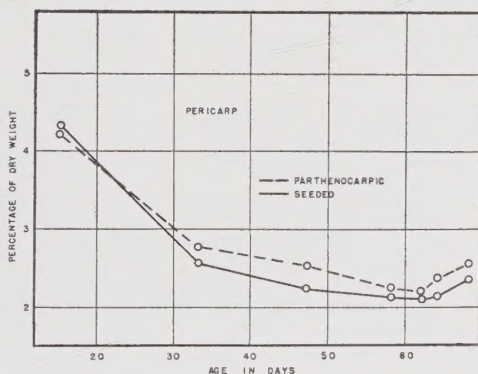


FIG. 3. Changes in the nitrogen content of the pericarp of the parthenocarpic and seeded pepper fruits.

DISCUSSION

It has been suggested (5) that there might be either (a) a difference in nutrient utilization due to seed formation, or (b) a difference in kind and concentration of enzymes or growth regulating substances due to the presence or absence of seeds as possible explanations of the differences between parthenocarpic and seeded tomato fruits. The high carbohydrate content of the parthenocarpic tomato fruits seemed to offer some support to the theory of difference in nutrient utilization. The same amount of organic nutrients might have entered both the parthenocarpic and seeded fruits but due to the greater metabolic activity required for development of seeds, the seeded fruits utilized more organic nutrients and thus had a lower concentration. However, the difference in acid content and size of the fruits could not be explained in this way. These later differences are controlled to a large

extent by enzymes or other regulating substances. If there is a difference in the enzyme or hormone content, it must be due directly to the presence or absence of seeds. Since the fruits for all practical purposes may be considered to have developed from identical ovaries, any difference in the concentration of these regulatory substances must have originated in the seeds. The data reported in this paper on the differences between parthenocarpic and seeded peppers also seems to indicate that the seeds are a source of enzymes which control the metabolism of the fruit. There was no difference in the proportion of different carbohydrates in the two types of pepper fruits, but merely a difference in concentration. The differences in size and shape of the two fruits also indicate the presence of some growth regulatory substance in the fruit which probably originated in the seeds.

While most of the evidence seems to indicate that the differences are due to differences in regulatory substances, it is also probable that the difference in the utilization of nutrients by the seeds is also a factor in determining the chemical composition of the two types of fruits.

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